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the drift is thin and at many places patchy and often represented only by scattered boulders. In fact, the country between Topeka and the glacial border west of Lawrence (see map) shows no more conclusive evidence of glaciation than the region south of it. Unless the topography at the time of the ice invasion was entirely different from what it is now, the streams coming from the melting glacier could not have had a high gradient and therefore should have dropped more and larger boulders near the ice edge and carried the smaller ones farther away.

(5) The erratics are not confined to any topographic position neither are they limited in elevation. Some are found in the valleys others on the slopes and still others on the uplands. The previously known drift was mapped as occurring in strips or else confined to definite channels in the region of the Wakarusa Valley,* as indicated before, the erratics are now known to be widespread and careful checking of barometric readings made at the exposures show variations of 30, 50, and more than 100 feet within short distances. Streams usually deposit their materials along definite channels and in such a manner that practically very little difference in elevation exists within short distances. Therefore, the disregard for elevation together with the lack of definite arrangement or distribution of the deposits favor direct deposition by the ice rather than by streams coming from the glacier.

(6) According to the previous mapping* the ice sheet crossed the valley of the Kansas River about seven miles northwest of Lawrence. Between that point and Kansas City the valley was unoccupied by the ice. It is therefore difficult to account for the numerous and widespread erratics south of the river between the two cities mentioned above for between the erratics and the melting ice sheet lay the trough of the river which undoubtedly must have served as the main outlet for the drainage coming from the glacier.

In conclusion, the writer is convinced from his study of the erratics that an ice sheet extended beyond the limits of the mapped glacial border and reached as far south as is indicated on the accompanying map, Plate I.

*J. E. Todd, "Kansas During the Ice Age", Trans. Kansas Acad. Sci. Vol. XXVIII, (1917), p. 36; Plate XI "Map of Pleistocene Formations of Northeastern Kansas." Pan-American Geologist, Vol. XL, (1923).

**J. E. Todd, op. cit., Map 1, Plate XI.

Additional Evidences of an Ice Invasion South of Kansas River in Eastern Kansas

Paper 26a of the 1927 Meeting at Lawrence
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In a paper "Glacial Erratics in Shawnee, Douglas and Johnson counties, Kansas", read before the Kansas Academy of Science in 1924, the conclusion was reached from a study of glacial erratics that

an ice sheet extended beyond the limits of the previously mapped glacial border in Eastern Kansas. Since that time, field investigations carried on in the region of the attenuated drift border have yielded additional evidences of the ice extension. The evidences are (1) true till, (2) reworked till, and (3) glacial striae.

True Till Deposits

Undoubted evidence of the extension of the ice sheet is established by the finding of true till at two localities. The first of the two exposures is at Haskell Indian Institute located at the south city limits of Lawrence and eleven miles south of Todd's glacial border. The other deposit is three-fourths of a mile south and one mile east of the Haskell locality in the northeast corner of NE 1-4, sec. 17, T. 13S, R. 20E. Except for the presence of numerous erratics lying scattered over the surface no indications of an existing till at the two localities were to be seen. In each case the till was discovered through the process of excavating. The Haskell deposit was uncovered at the time of the building of the Haskell stadium while leveling the athletic field by means of the steam shovel, digging trenches for drainage purposes and sites for foundations. At the western edge of the athletic field the overburden was removed from an area of about an acre and to a depth of five feet. The excavation thus made revealed a true till. A better exposure, however, was brought to light in a trench from ten to twelve feet deep dug on the south side of the west end of the athletic field. Here, although less of an exposure, the material was to be seen at a better advantage because the till was undisturbed. The following materials were exposed:

- | | | |
|--|--------|---------------|
| 1. Black loamy soil ----- | 2 feet | inches |
| 2. Red sandy soil ----- | 2 feet | inches |
| 3. Band of black silt or soil, containing an occasional quartzite pebble and grading gradually and irregularly into the till beneath, from ----- | | 6 - 12 inches |
| 4. Very red, tough till, thoroughly leached and filled with erratics of various kinds and sizes, exposed to bottom of trench ----- | 8 feet | inches |

The erratics in the tough red till ranged in size from pebbles less than one-fourth of an inch to boulders one foot in diameter and consisted chiefly of red to pink quartzites with some well decayed granites and greenstones. There are two tills represented in the above section. The upper till is decidedly different from the lower one in being less clayey, thinner and containing erratics much smaller in size. The two tills are separated by the black silty band or soil indicated in the section. This deposit is at the edge of the upland overlooking the valley of Wakarusa Creek and about 50 feet above its flood plain.

The other deposit of till to the southeast of the one just described is essentially similar to the lower eight feet of the Haskell exposure, excepting that granites and greenstones are more abundant and on the average larger. This deposit is also on the upland overlooking Wakarusa Valley and is at an elevation of 870 feet above sea level

or 10 feet lower than the one first described. As in the first case, numerous quartzite boulders dotted the surface without showing any traces of a till beneath. The till was discovered while digging a trench four feet deep to the top of the Western Sandstone.

Although only two localities of true till have thus far been located other deposits undoubtedly exist hidden as those just described and only through the building of new roads, excavations for foundation sites and drainage ditches will they eventually come to light.

Reworked Till Deposits

Although true till deposits are scarce, deposits of till partially reworked by rain, gravity and other agents are fairly numerous and widely scattered. It was the finding of these till-like deposits that first aroused the writer's interest and attention to the possible extension of the ice sheet in Kansas. The material at the till-like outcrops is exposed in road cuts from 100 to 200 feet long and generally about three feet deep. In all cases the drift is composed of a brown to red, more or less sandy, often sticky clayey material, thoroughly leached and containing numerous pebbles and boulders. The coarse materials consist chiefly of red quartzite, well decayed granites, brown to white cherts some of which crumble to a fine white powder on even the slightest pressure, gneisses, schists and sandstones. In size the pebbles average less than one-half of an inch in diameter. The larger boulders measure from one to two feet in diameter and consist for the most part of red Sioux quartzites. A loess-like silt covers the deposits in most places. The deposits just described are without question tills which subsequently have been reworked. This is evidenced by the partial rearrangement of the materials into irregular layers of pebbles and boulders following the contour of the topography. The materials show no true stratification. The position of the deposits on the uplands and divides also precludes any other origin but glacial deposition.

Glacial Striae

A third evidence of the ice extension is indicated by the presence of glacial striae several miles east of Eudora and located south of the mapped glacial border. These striae were not observed by the writer but were reported to him by Dr. Twenhofel of the University of Wisconsin who had seen them a number of years ago.

Summary and Conclusion

Summing up the evidences of the tills both the true and the reworked deposits, the glacial striae beyond the limits of the old glacial border and the erratics previously reported, the writer is convinced that an ice sheet extended beyond the limits of the mapped glacial border and reached as far south as is indicated on the accompanying map, Plate I.